# DISTRIBUTED NETWORK ARCHITECTURES FOR NEXT-GENERATION CABLE ACCESS


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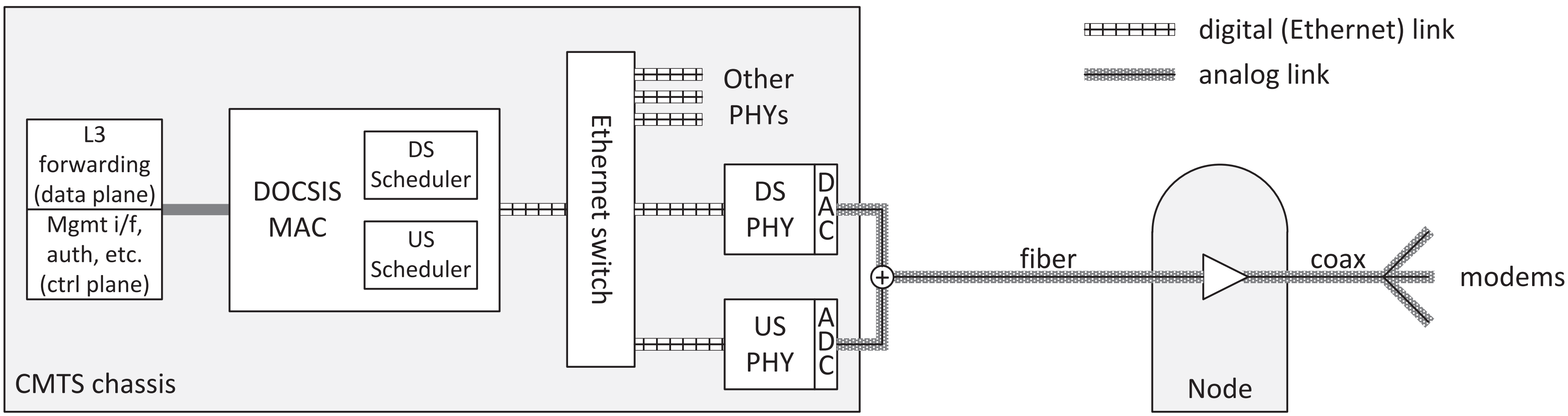
# Why Distribute the CMTS?

Distributed CMTS concepts have been considered for a long time, but integrated platforms still dominate the market. Why reconsider distributed architectures now?

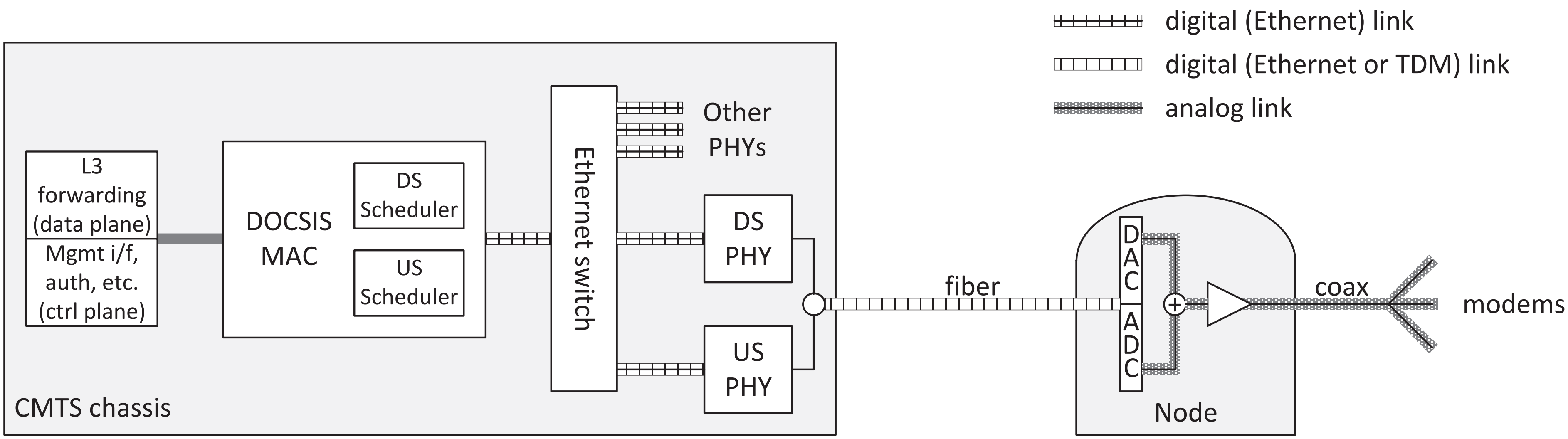
- Replacement of analog lasers with digital links can improve plant SNR and reduce cost
- Some operators foresee pressure to reduce headend/hub space and power requirements
- Technology marches on! A complete bidirectional digital channel lineup can now be generated in a fiber node.
  - Chip densities have increased
  - Direct digital synthesis of the downstream is becoming common
  - Power consumption per megabit has decreased

# Integrated CMTS Architecture



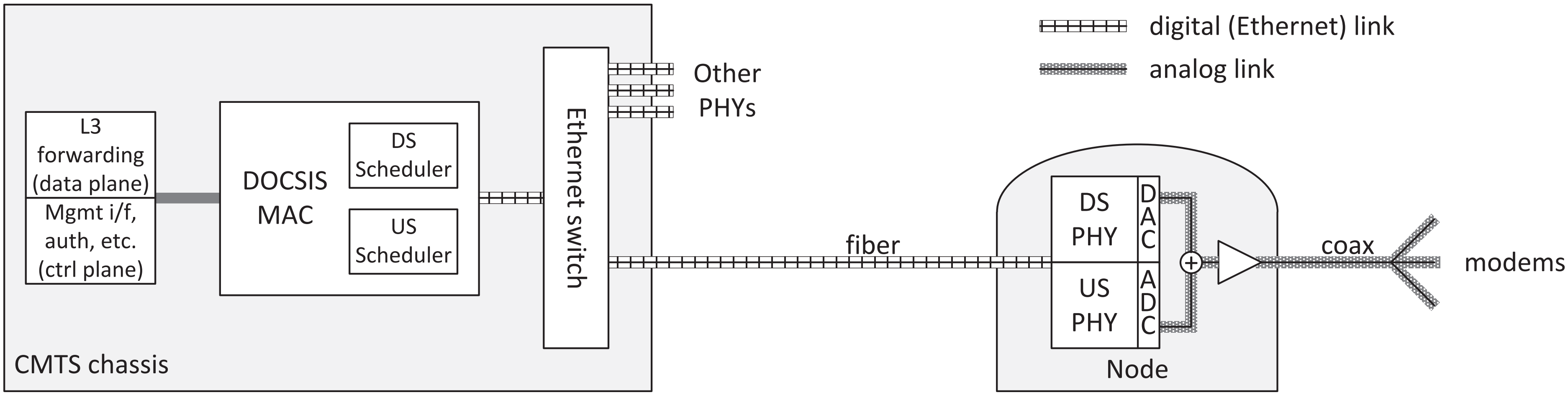

- Note use of Ethernet as a many-to-many interconnect for the MAC-PHY interface internal to the CMTS
  - This is common in many existing platforms

# “Remote DAC/ADC” Distributed Architecture



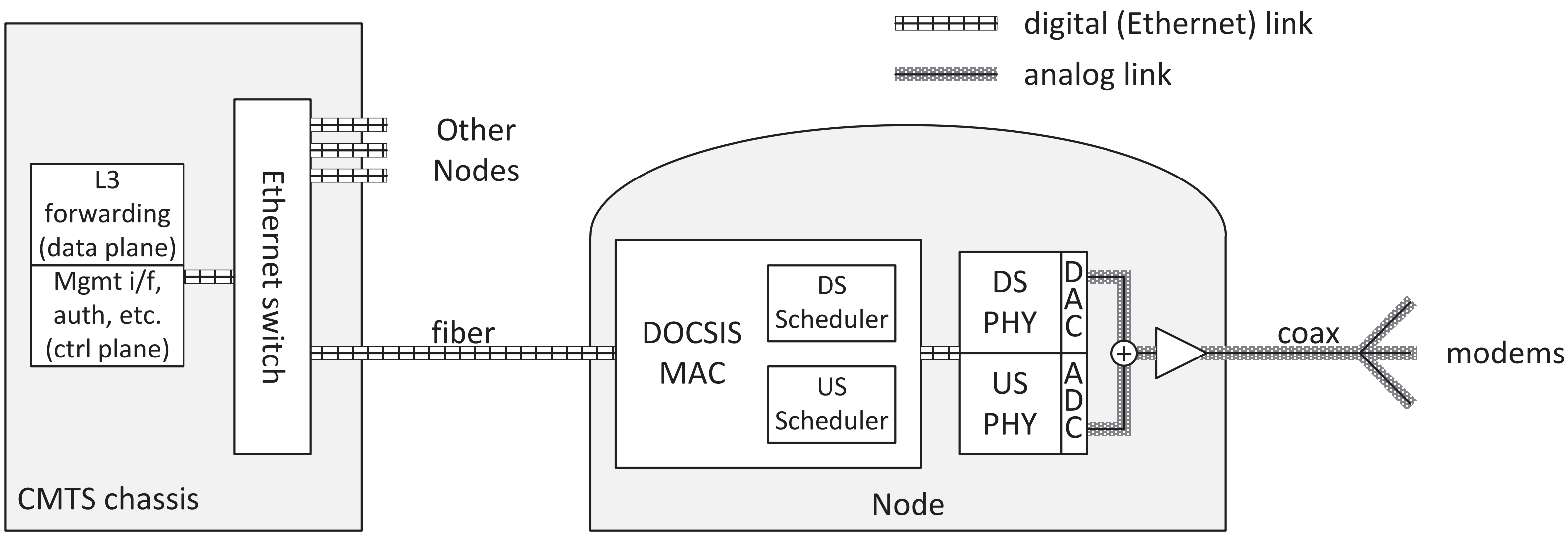

- DAC and ADC are located in the node
- Samples representing the RF signal are transferred across a digital fiber link
  - Analog RF signals are present only on coaxial segments
- The resulting SNR improvement is common to all distributed architectures considered in this paper
- Current example: “Digital return” technologies/products

# "Remote PHY" Architecture




- Complete downstream and upstream PHYs are moved to the node along with DAC and ADC
- Ethernet switching interface currently internal to the CMTS is extended across the fiber link to the node
  - Takes advantage of a logical "breakpoint" inside the CMTS
- Current example: DOCSIS® Modular Headend Architecture (MHA) (aka M-CMTS)

# “Remote MAC-PHY” Architecture




- Node also contains DOCSIS® MAC, including upstream and downstream schedulers and related message processing
  - Different versions locate upper-layer MAC, Management, and Layer 3 functions in various places
- Current examples: C-DOCSIS I and C-DOCSIS II architectures from C-DOCSIS (China DOCSIS) specification

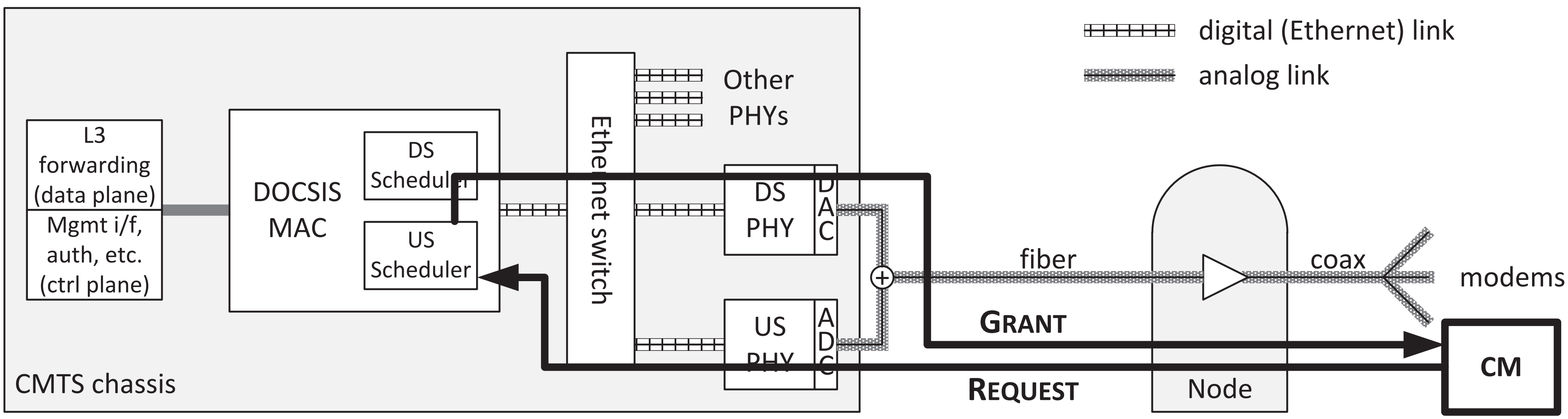
# Comparison of Required Network Throughput

- Data throughput requirements are an important cost driver for the digital link in a distributed system
- Remote PHY and Remote MAC/PHY require network capacity approximately equal to the peak line rate of services delivered (plus protocol overhead, say up to 10%)
- Remote DAC/ADC must transfer digital samples of sufficient resolution (14/12 bits), taken at a rate >2x the RF bandwidth
- Required network throughput is much higher for Remote DAC/ADC

| | | |
|---|---|---|
| Maximum Possible Downstream Rate: | | |
| Remote DAC/ADC | 44100 | Mbits/second |
| Remote PHY and Remote MAC-PHY | 12601 | Mbits/second |
| Maximum Possible Upstream Rate: | | |
| Remote DAC/ADC | 9450 | Mbits/second |
| Remote PHY and Remote MAC-PHY | 2578 | Mbits/second |

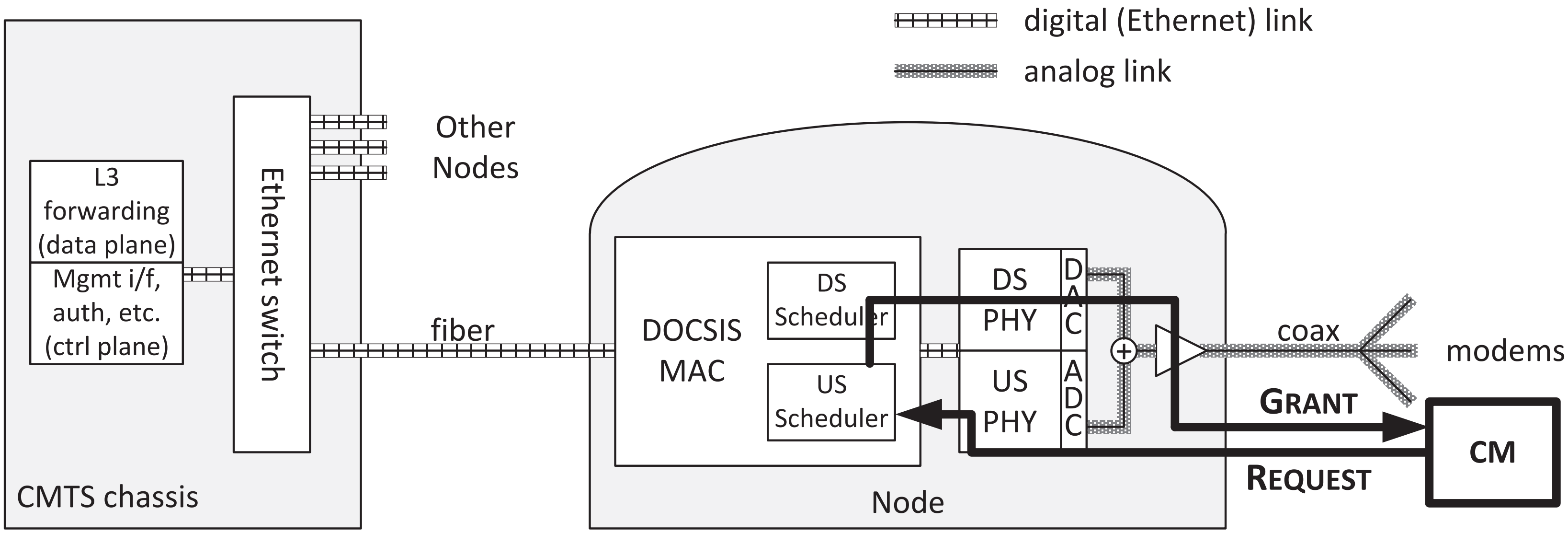
# DOCSIS Round-Trip Time Comparison

- DOCSIS Round-Trip Time impacts system performance:
  - Largest component of the DOCSIS® network's contribution to end-to-end latency for business or gaming services
  - Affects "access latency" seen at startup of TCP protocol; high values can hurt TCP performance for web browsing and similar activities
- Request-Grant path for Integrated architecture is shown below



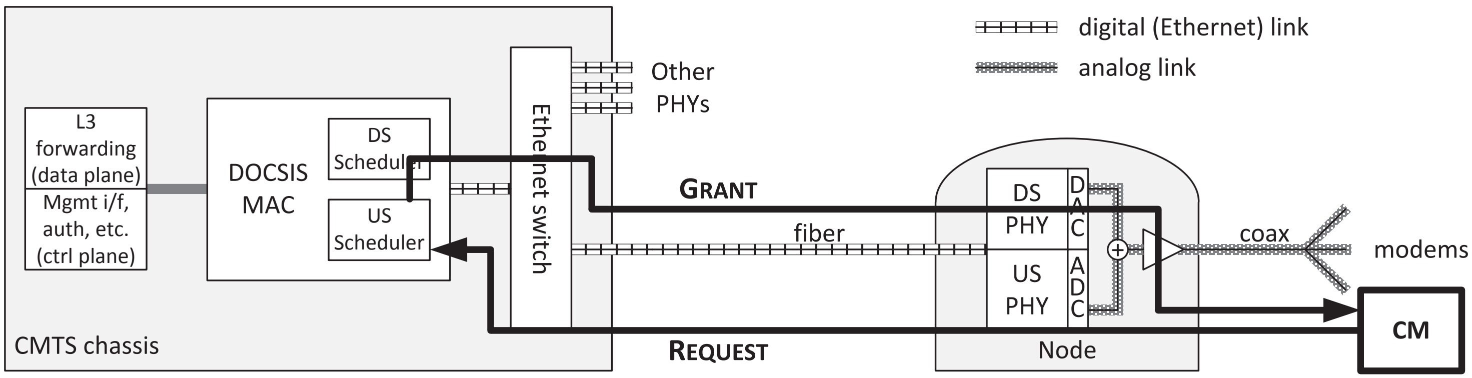
# Round-Trip Time For Remote MAC-PHY

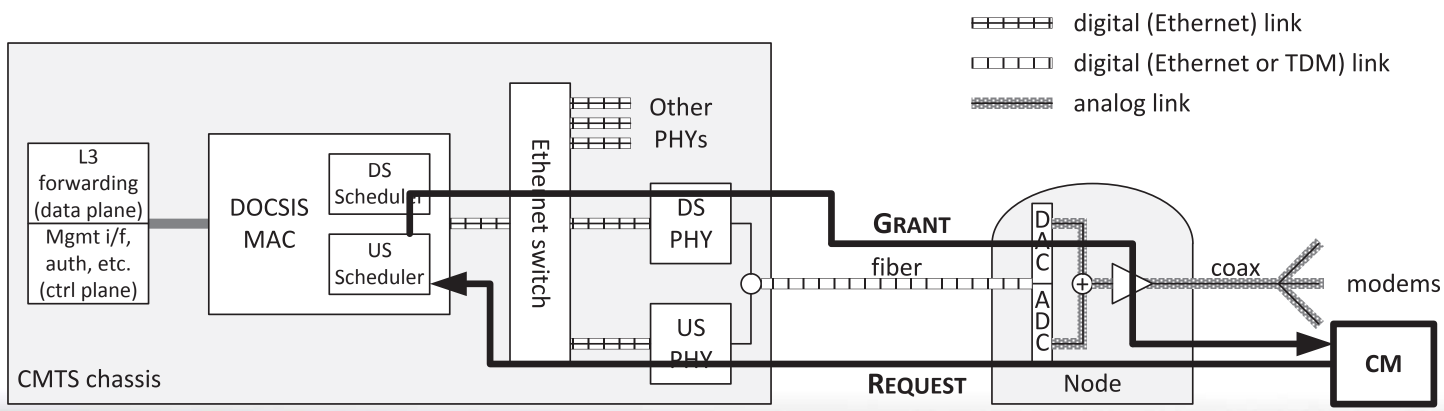
- Same CMTS components traversed, but over coax segments only
- Round-Trip Time is reduced by the propogation delay of the fiber
- Possible performance improvement depending on fiber link distance



# Round-Trip Time for Remote PHY and Remote DAC/ADC

- Same as integrated case *IF* network topology of Ethernet link over fiber is unchanged from internal topology of Integrated architecture



# Network Topology and Planning

- If the topology assumption from the previous slide does not hold, then careful network planning is required
  - Characterize and shape all traffic on the link
  - Calculate and bound maximum possible queueing delays at all potential congestion points
- Network jitter is a particular concern
  - For Remote PHY, jitter causes delay due to head-of-line blocking
  - For Remote DAC/ADC, excess jitter may cause buffer underruns, with potentially catastrophic results (e.g. dropped modems)
- In planning the network, jitter should be treated as another delay component and added directly to the delay budget

Allowing uncontrolled/uncharacterized traffic on this link is NOT recommended!

# Protocol Complexity

- In general, simpler protocols are easier to standardize, implement, and deploy, provided they are adequate for the task at hand
- In the control plane, the Remote MAC-PHY architecture carries the most information, while Remote DAC/ADC carries the least
- In the data plane, Remote MAC-PHY may require little to no additional tagging of packets to carry required per-packet information
  - Example: C-DOCSIS II CDT protocol
- The Remote PHY data plane requires an extra layer of Ethernet/IP headers to tunnel packets between headend and node, plus more per-packet information
  - Example: DEPI

| | Data Plane | Control Plane |
|---|---|---|
| Simplest | | |
| \| | Remote DAC/ADC | Remote DAC/ADC |
| \| | Remote MAC-PHY | Remote PHY |
| \| | Remote PHY | Remote MAC-PHY |
| V | | |
| Most Complex | | |

# Conclusion

- On the points of comparison studied here, there is no clear winner – each approach has its pros and cons
- All approaches are technically viable and potentially useful in various ways
- Comparing classes of architectures and examining existing examples of each can be instructive in understanding future proposals

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